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WEPTASK NO: RA1200001
PROBLEM NO: BIS 21256
DATE: 1 Sept 1964

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9-17-64

NATC REPORT OF TEST RESULTS

FROM
Commander, Naval Air Test Center

TO
President, Board of Inspection and Survey

WEPTASK	PROBLEM ASSIGNMENT	EFFORT LEVEL	AIRCRAFT BUNO
RA1200001	BIS 21256	Maximum	150532/150534

PROJECT TITLE
Abbreviated Tests of the AN/APA-143 Antenna in Conjunction with BIS Evaluation of the E-2A Airplane; Sixth Interim Report

DATES OF TESTS	LOCATION OF TEST	COGNIZANT BUWEPS DIVISION
21 Jul 1964, 11 and 13 August 1964	NATC	RAAV-8
NATC PROJECT OFFICER/ENGINEER	**NATC DIVISION**	**COGNIZANT BUWEPS ENGINEER**
M.C. Fairall/R.C. Murphy	WST	Mr. L. M. Puckett

ENCLOSURES
☐ PHOTOGRAPHS ☐ DRAWINGS ☐ TABLES ☐ CURVES ☐

RESULTS (Introduction, Results and Discussion)

Ref: (a) General Electric Special Study Report No. 52 of 13 Apr 1961, AN/APA-143 Radar Antenna Side Lobe Reduction Study

1. Radar system performance of the E-2A airplane during BIS evaluation indicated deficiencies in the radiation characteristics of the AN/APA-143 antenna system. Limited flight tests and ground tests were initiated to determine possible explanations for the observed deficiencies.

2. The APA-143 antenna system specified parameters are:

a. Gain above isotropic radiator - 21 db

b. Horizontal beamwidth - 6.8 degrees

c. Vertical beamwidth - 21 degrees

This system is coupled to the AN/APS-96 radar having a pulse-repetition frequency of 300 pps, a pulse width of 12.8 μsec and a peak power output of 1000 kw.

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Flight Tests

3. Radar transmissions from the E-2A airplane, BuNo 150532, were recorded in a P-2E airplane as a function of range as the airplanes flew toward each other (nose toward nose aspect) and as the airplanes flew away from each other (tail to tail aspect). The E-2A airplane was flown at altitudes of 5,000 and 15,000 feet. The P-2E airplane was flown at an altitude of 10,000 feet. The flight paths made over open sea along the 38th parallel, 200 miles east of NATC, are shown in figure 1.

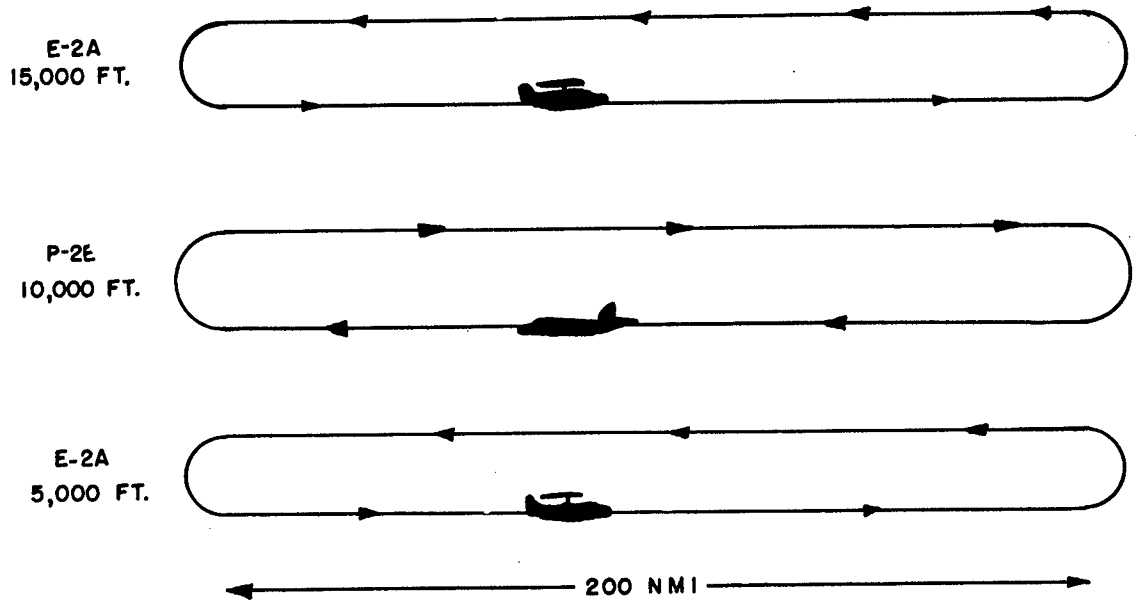

Figure 1
Flight Paths Used for Airborne Radiation Measurements

4. The APS-96 radar in the E-2A transmitted through the continuously rotating APA-143 antenna at a frequency of 446.0 mc. The signal level was recorded in the P-2E airplane through an AT-141/ARC UHF antenna, an AN/APR-9 countermeasures set and a Brush Mark II recorder. Range between airplanes was determined by the APS-96 radar, and five-mile marks were recorded on the data plots. Due to the abbreviated tests, pattern information of the AT-141 antenna installed on the P-2E airplane was not obtained. The AT-141 antenna is bottom mounted at an extreme outboard position on the fuselage and forms an approximate angle of 45 degrees with the horizontal plane. The antenna is sensitive to both horizontally and vertically polarized signals. A block diagram of the radar signal monitoring system is shown in figure 2.

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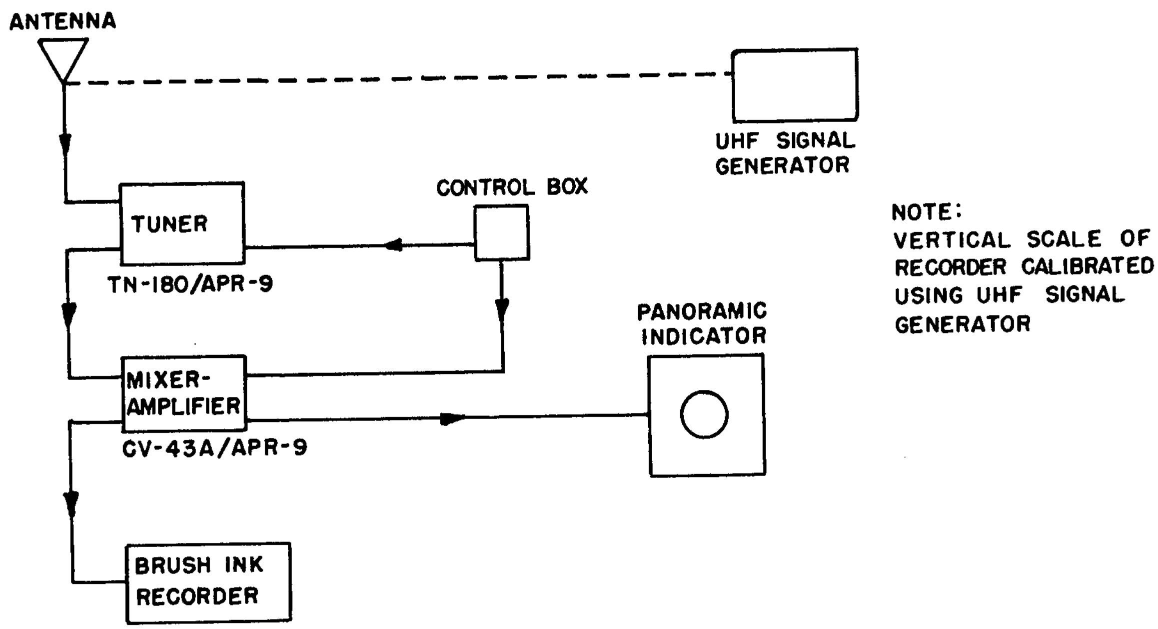

Figure 2
Block Diagram of Signal Monitoring System

Ground Tests

5. Ground tests were conducted to obtain radiation patterns of the APA-143 antenna at aspect angles every 15 degrees in the azimuth plane around the airplane. The E-2A airplane, BuNo 150534, was positioned on a compass rose that is calibrated in 15-degree increments. A receiving antenna and recording van was located 1,000 feet from the airplane in the far field of radar antenna. A cw signal at a frequency of 437.2 mc was transmitted through the continuously rotating APA-143 antenna. The airplane was positioned at each of the twenty-four 15-degree headings. The signal was recorded during three sweeps of the APA-143 antenna at each heading.

6. Figures 3 and 4 present plots of the peak power received at the AT-141 UHF antenna terminals with the E-2A airplane flying at 15,000 feet altitude and the P-2E airplane flying at 10,000 feet altitude. Figures 5 and 6 are plots of the peak power received with the E-2A airplane at 5,000 feet and the P-2E at 10,000 feet. The plots of figures 3 through 6 are not continuous curves since the data were sampled only at slant range increments of 5 miles.

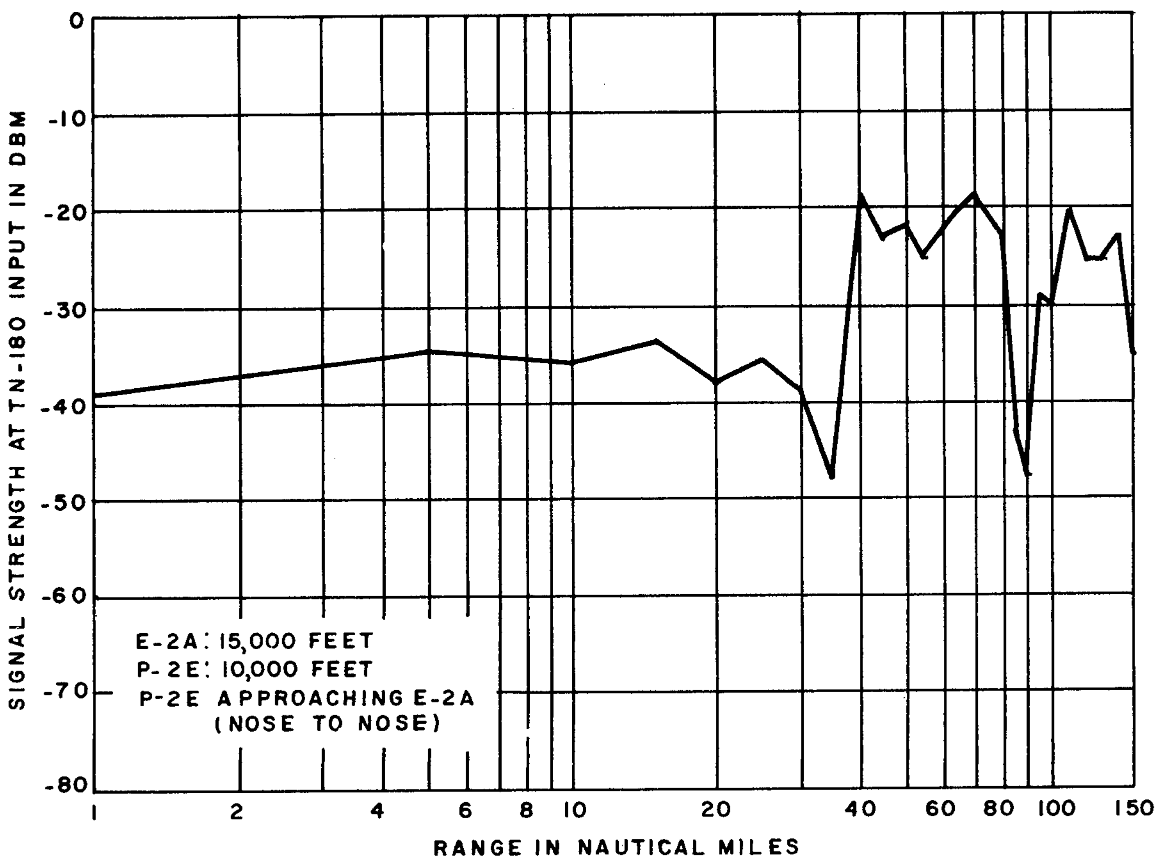

FIGURE 3

RELATIVE SIGNAL STRENGTH VS RANGE OVER OPEN SEA

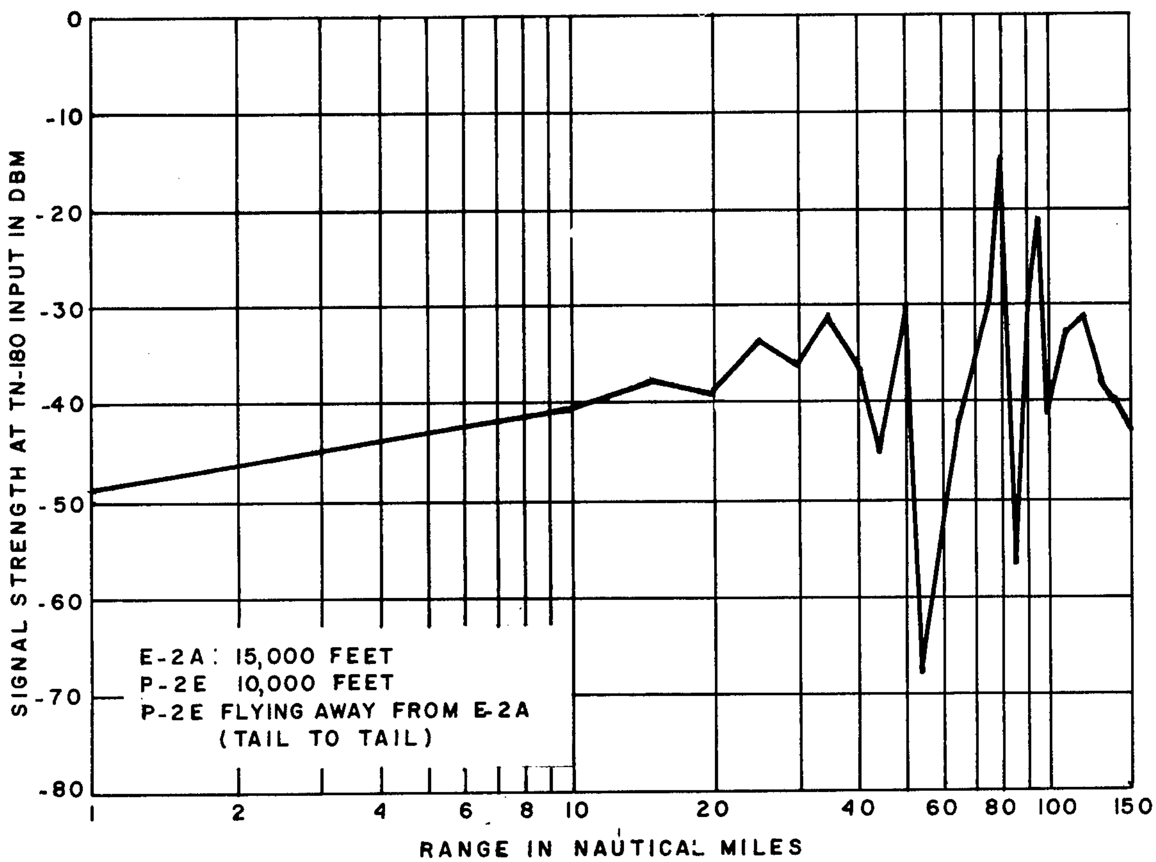

FIGURE 4

RELATIVE SIGNAL STRENGTH VS RANGE OVER OPEN SEA

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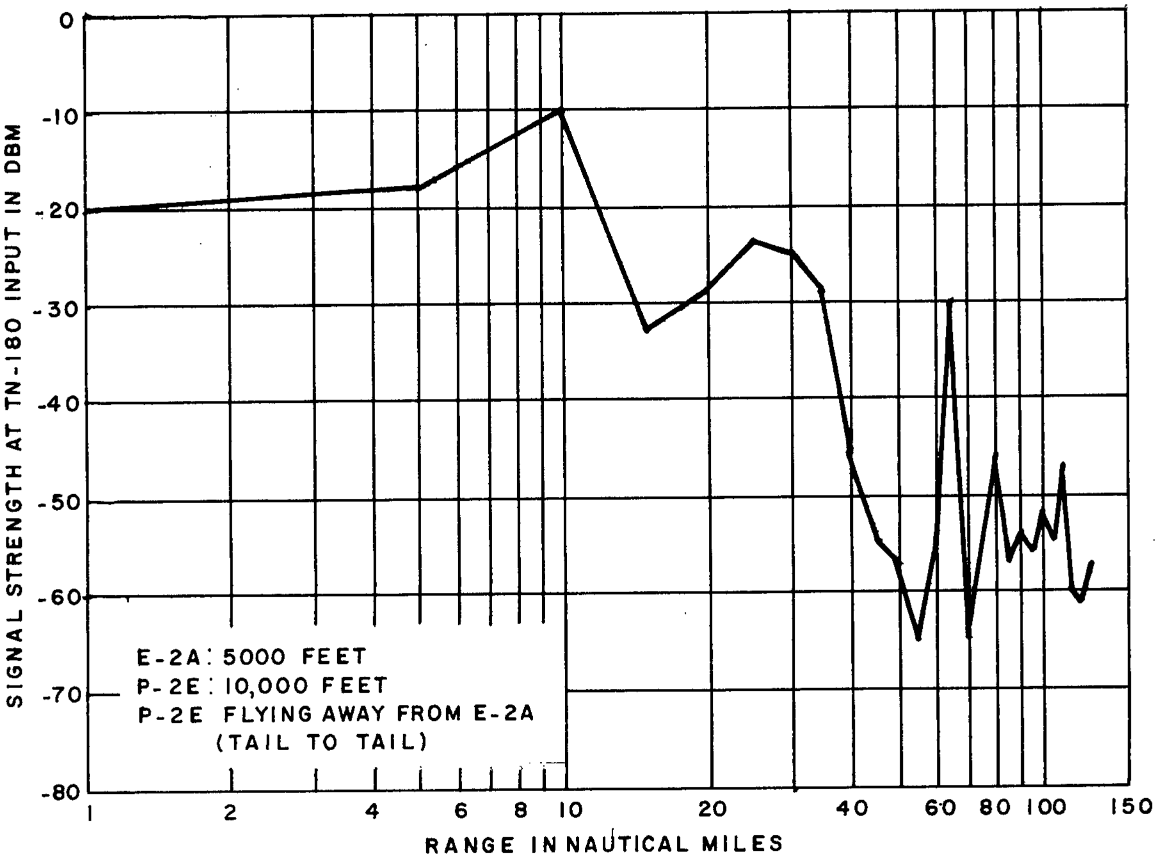

FIGURE 5

RELATIVE SIGNAL STRENGTH VS RANGE OVER OPEN SEA

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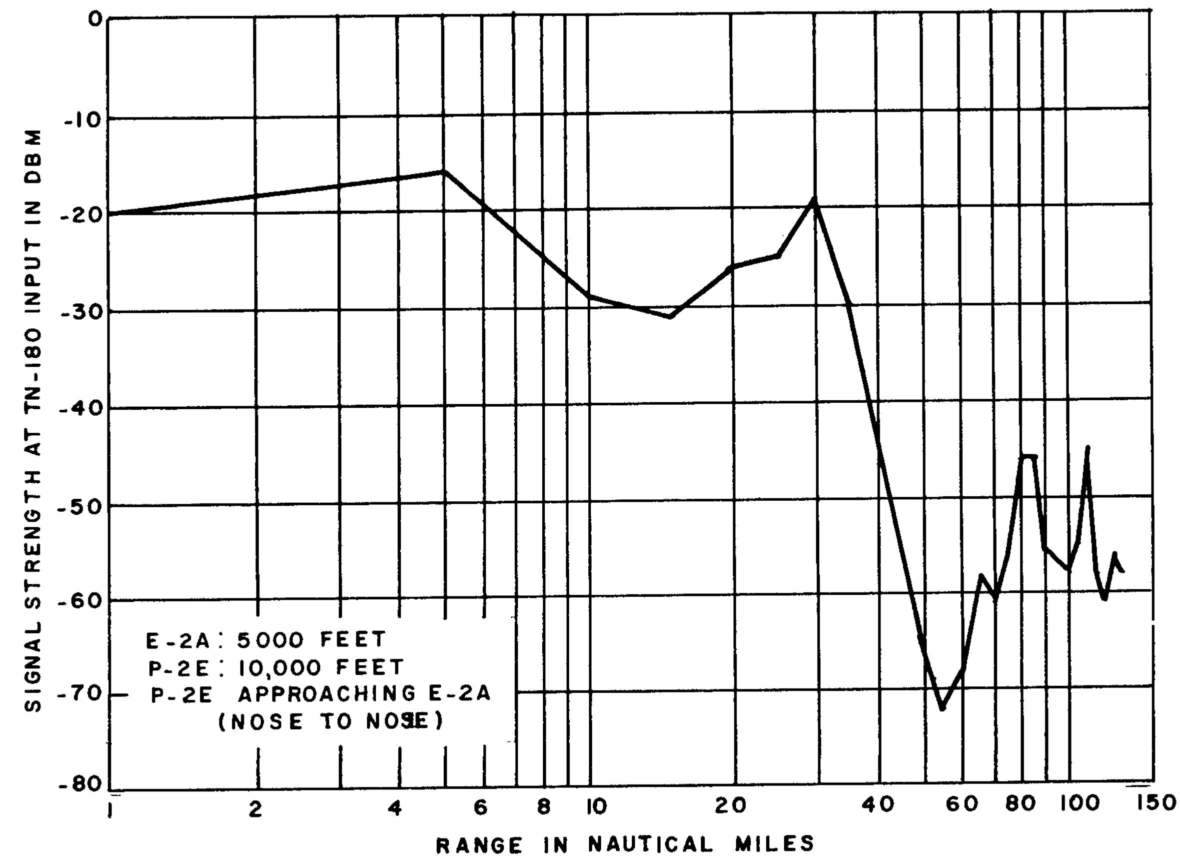

FIGURE 6
RELATIVE SIGNAL STRENGTH VS RANGE OVER OPEN SEA

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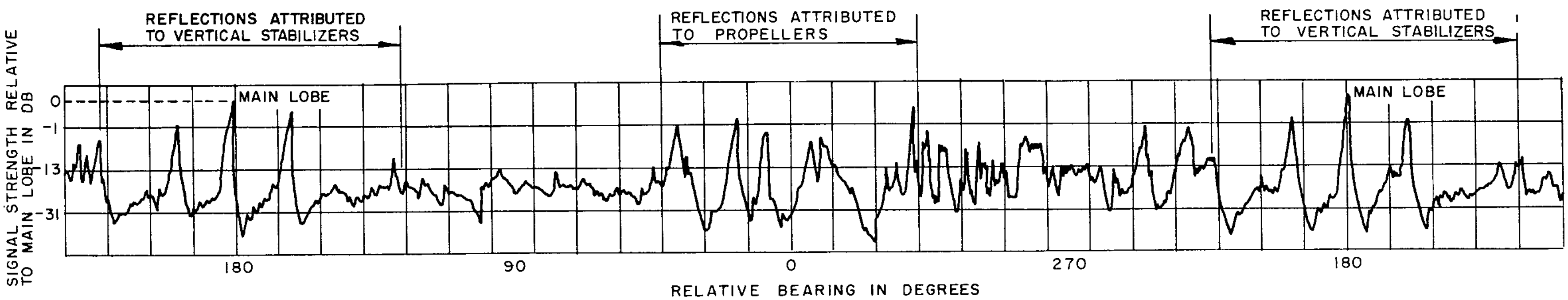
7. Figures 3 and 4 show the received signal increases as the slant range between airplanes increases to 40 miles. This indicates that the normal 6 db per range octave decrease in power is compensated by the increase gain of the radar antenna as the P-2E airplane moves into its main beam. At slant ranges beyond 20 miles and up to the maximum airplane separation of 150 miles, the elevation angle between the airplanes remains nearly constant with both airplanes remaining approximately situated in the same azimuth plane. Therefore, signal level fluctuations which commence at airplane separations of approximately 20 miles are due either to changes in the azimuth aspect of the airplanes or to propagation effects or to a combination of both. However, propagation effects such as interference patterns set up by multipath radiation reflected off the sea water would appear to be the most probable cause due to the repeating characteristics of the signal. Between 30 and 50 miles, the full compensation between decreased received power due to slant range and increased received power due to antenna gain is achieved. Consequently beyond this range an approximately normal decrease in power for increased slant range occurs if an average of the fluctuating signal is taken.

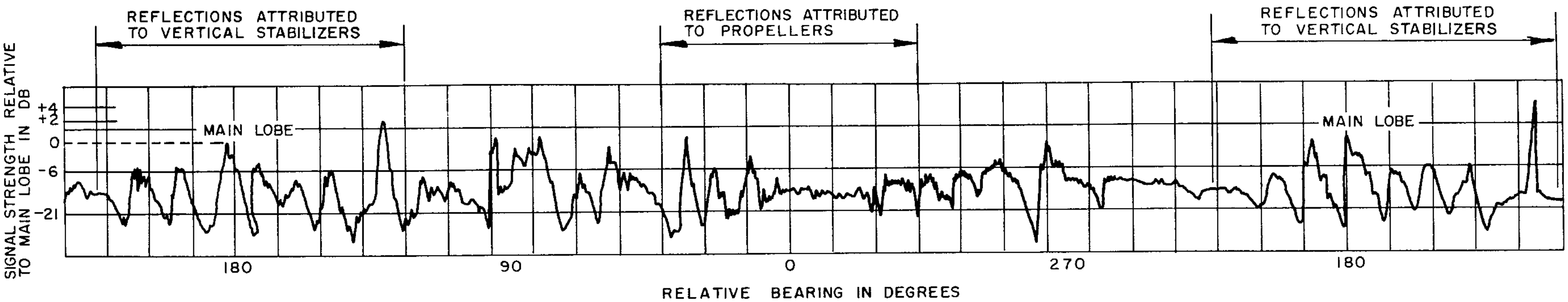
8. In figures 5 and 6, the P-2E airplane flying above the E-2A appears to situate in the main radar beam at a much shorter separation range of approximately 10 miles. Beyond this range, the level of the average value of the fluctuating signal decreases roughly at a normal rate. The fluctuating signal level is again probably due to vectorial addition and subtraction of multipath signals arriving at the AT-141 antenna.

9. Figure 7 contains samples of the data recorded in flight during one sweep of the E-2A radar antenna. The P-2E airplane (10,000 feet) was flying away from the E-2A airplane (5,000 feet) on a reciprocal heading. Multiple lobes are evident in both data samples which were taken at ranges of 15 and 50 nmi. The multiple lobes appear to be the result of signal reflections from the vertical stabilizers and propellers of the E-2A airplane as the main beam of the radar traversed these areas. This assumption is based on a comparison of the geometry of the engines and tail surfaces when the main lobe was directed at them with the angular position of the detected lobes on the signal recording.

10. Figure 8 shows a plot of the signal received during ground tests at headings of 000 and 195 degrees relative to the airplane. Figure 9 presents a graph of the amount of suppression



ONE SWEEP OF AN/APA-143 ANTENNA AT 15 NMI SEPARATION RANGE – MAIN LOBE INTERCEPTED AT 180° RELATIVE TO E-2A HEADING

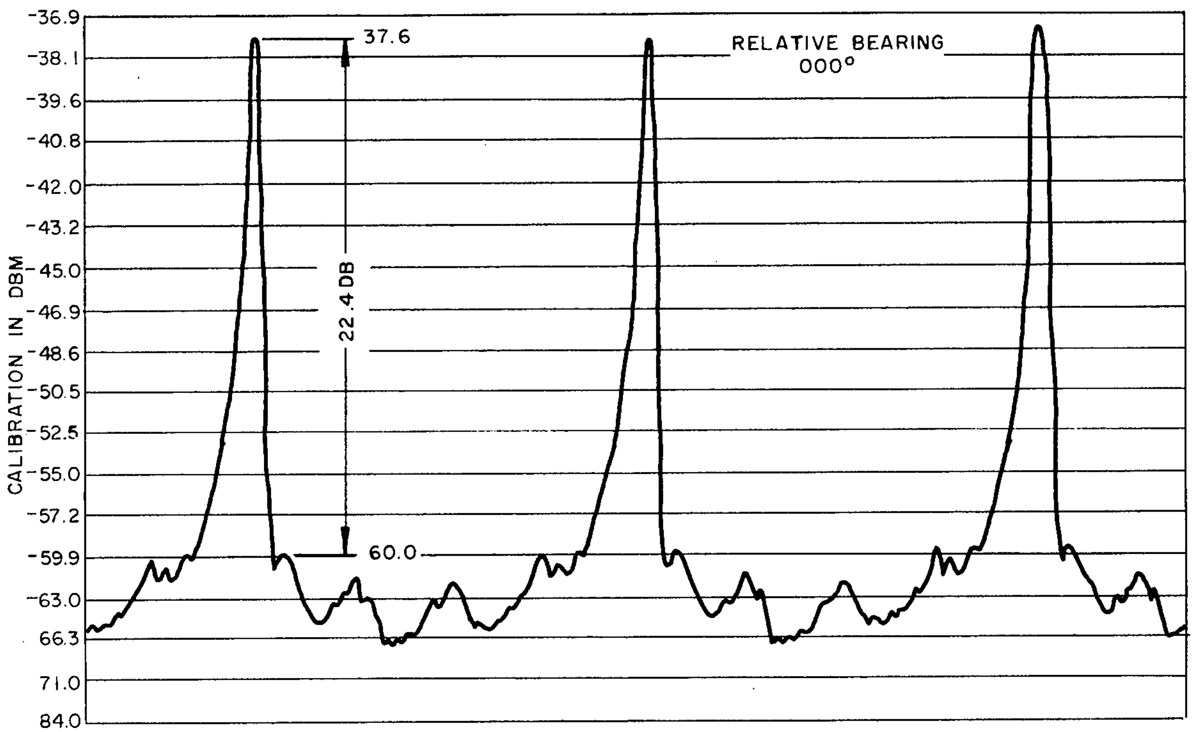


ONE SWEEP OF AN/APA-143 ANTENNA AT 50NMI SEPARATION RANGE – MAIN LOBE INTERCEPTED AT 180° RELATIVE TO E-2A HEADING

E2A AIRPLANE AT 5,000 FT. ALTITUDE
P2E AIRPLANE AT 10,000 FT. ALTITUDE

FIGURE 7

DATA SAMPLES OF THE RECEIVED SIGNAL RECORDED IN FLIGHT



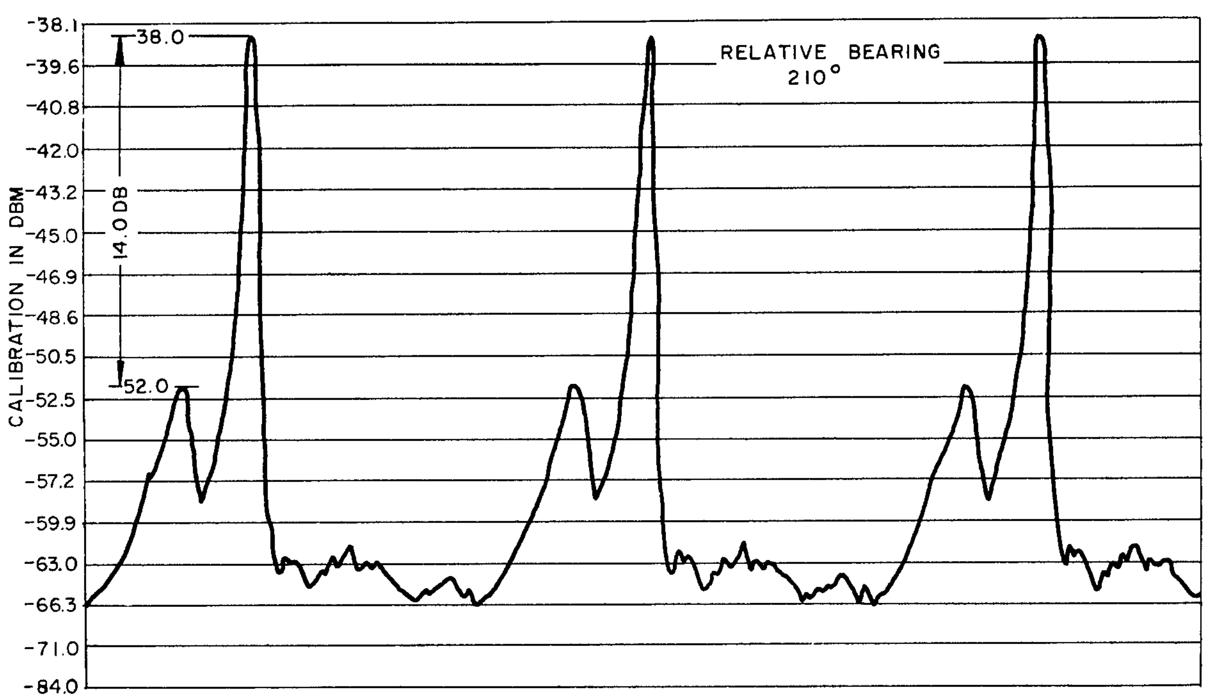
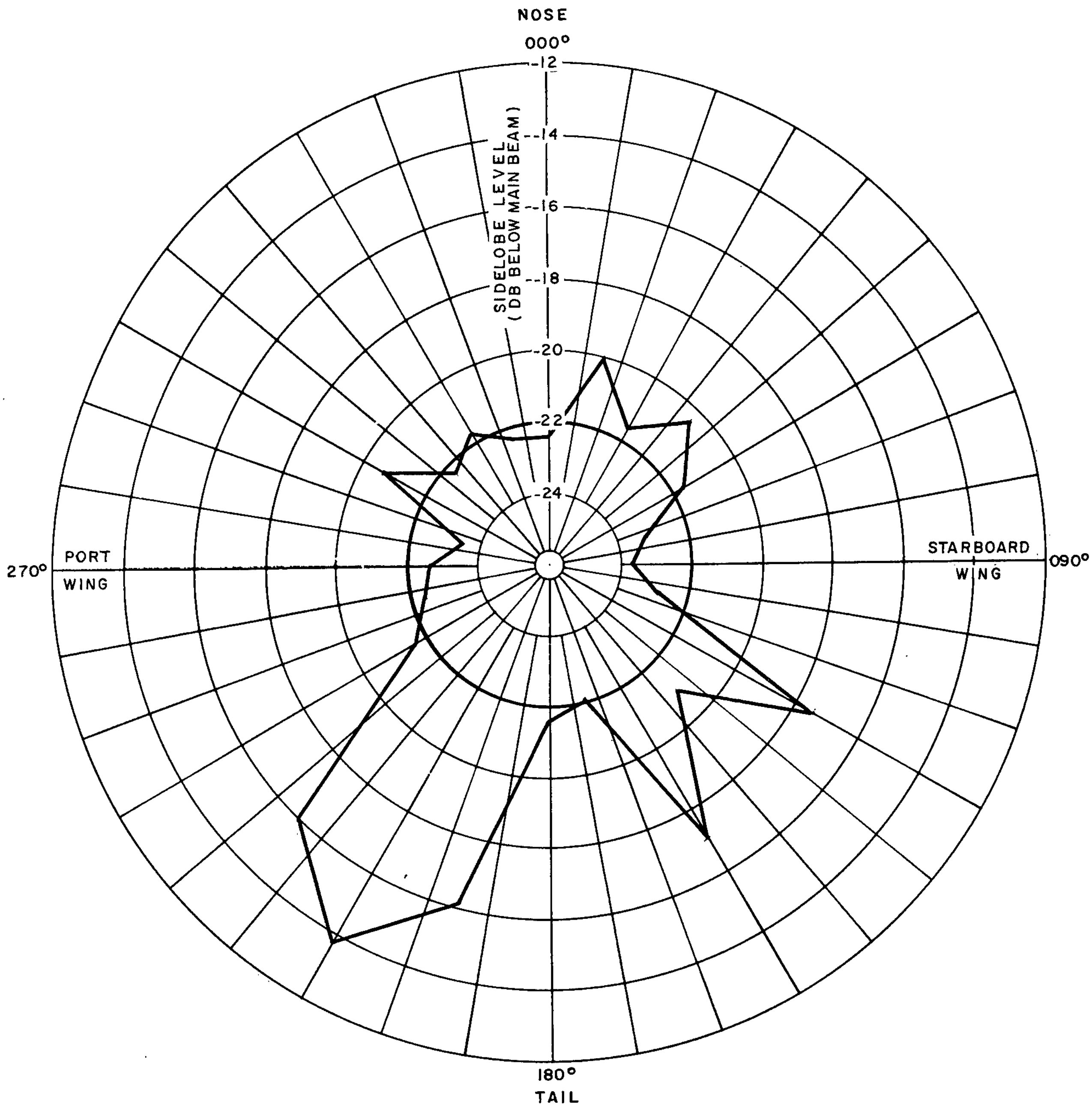


FIGURE 8

SAMPLES OF SIGNALS RECEIVED DURING GROUND TESTS



E-2A BUNO. 150534
GROUND TEST ON APA-143 ROTODOME
FREQUENCY: 437.2 MC
DATE: 21 JULY 1964

FIGURE 9

MAXIMUM SIDELOBE SUPPRESSION OF THE APA-143 ANTENNA VS AIRPLANE RELATIVE BEARING in db between the main beam and the maximum side lobe when the airplane is viewed at each 15-degree aspect angle around the airplane. Reference (a) states that a level of side lobe suppression of 26 db is desirable, and that a minimum tolerable side lobe suppression of 22 db is necessary to avoid overloading the computer detector system. Figure 9 shows that side lobes exceeding this 22 db level prevail at fifteen of the twenty-four headings. A side lobe with less than 15 db of suppression exists when the airplane is viewed from a relative heading of 210 degrees. Figure 10 is data recorded by GAEC during flight tests on 4 September 1962 at a frequency of 420 mc. Figure 10 shows at 13 of 24 headings the minimum suppression of 22 db is exceeded.

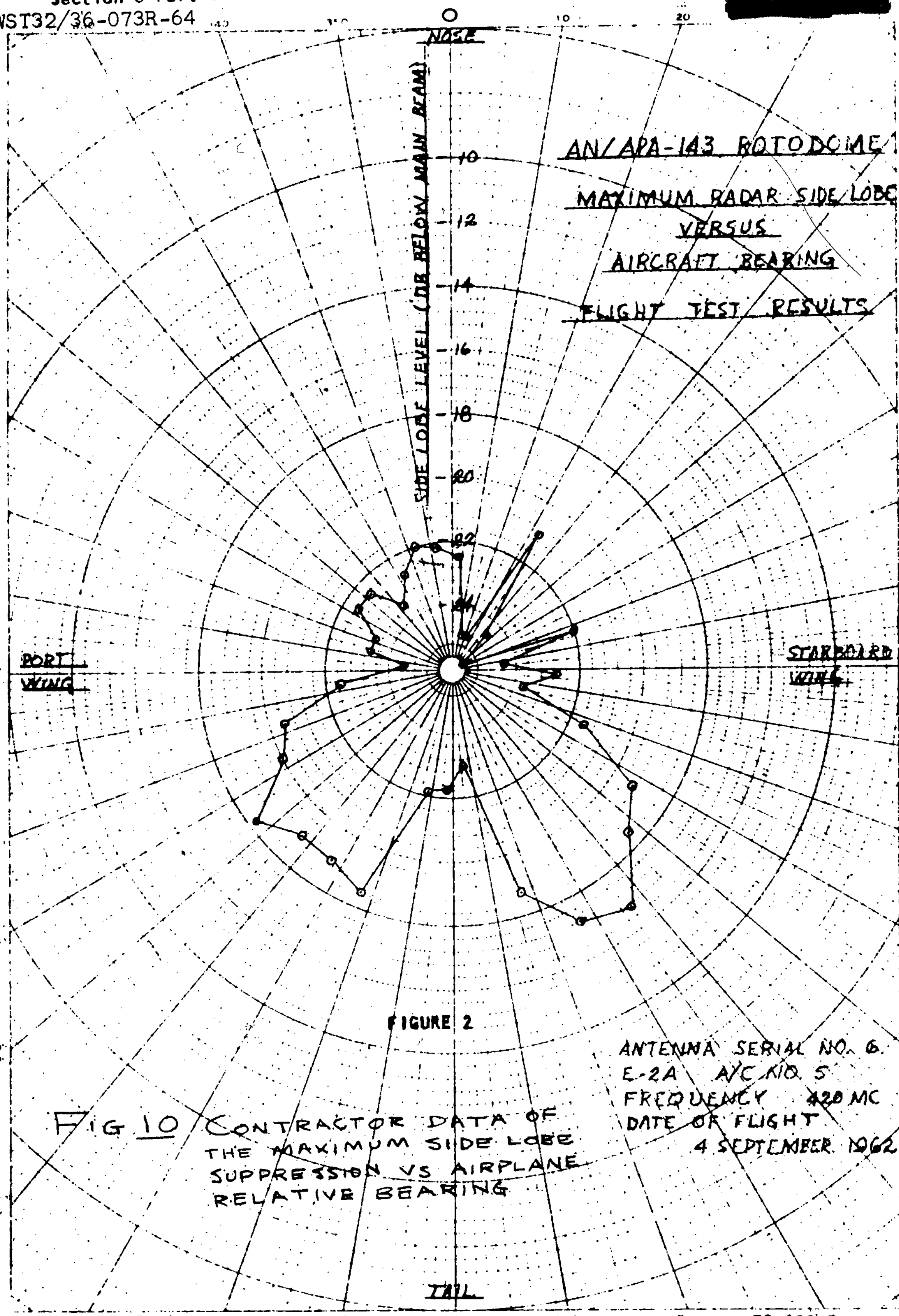


FIGURE 2

Fig 10 Contractor data of the maximum side lobe suppression vs airplane relative bearing

11. It is concluded that:

a. At airplane separation distances of 20 miles or more, the probable cause of fluctuating signal levels received at the AT-141 antenna terminals was due to multipath signal reflections from the sea water (paragraphs 7 and 8).

b. The multilobe data received during a single sweep of the APA-143 antenna were due to signal reflections from the vertical stabilizers and possibly from the propellers as the main beam of the antenna traversed these areas (paragraph 9).

c. The existing side lobes in the APA-143 antenna after installation on the E-2A exceed the minimum tolerable level for satisfactory operation of the computer detector (paragraph 10).

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